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IS 15447-2 (2008): Commercial blasting explosives, Part 2: Slurry/emulsion explosives [CHD 26: Explosives and Pyrotechnics]

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Indian Standard

COMMERCIAL BLASTING EXPLOSIVES

PART 2 SLURRY/EMULSION EXPLOSIVES — SPECIFICATION

ICS 71.100.30

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 2008

Price Group 4

Explosives and Pyrotechnics Sectional Committee, CHD 26

FOREWORD

This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards, after the draft finalized by the Explosives and Pyrotechnics Sectional Committee had been approved by the Chemical Division Council.

An explosive is a compound or a mixture of compounds, which when initiated by heat, impact, friction or shock undergoes a very rapid self-propagating exothermic reaction. This reaction produces more stable products, usually gases, that exert tremendous pressure as they expand at high temperature.

Explosives can be classified into two broad groups, namely, the industrial explosive and the military explosives. Industrial explosives are also known as commercial explosives and include dynamites, slurries, emulsions and blasting powders. Military explosives are mainly used as ammunition in small arms as well as field guns and rockets.

Slurries consist of saturated aqueous solution of ammonium nitrate and other nitrates which also contain additional amounts of undissolved nitrates in suspension. Fuels are added to the composition in order to take up the excess oxygen of nitrates. Sensitizer in slurries can be monomethylamine nitrate, dispersed air bubbles, aluminium powder, etc.

Emulsions are made by mixing an aqueous solution of nitrates of ammonium, calcium and/or sodium and fuels like oil, LSHS, diesel oil and waxes in the presence of emulsifiers. Sensitivity is normally achieved by adding chemical gassing agents like sodium nitrite and/or micro balloons.

In permitted slurry/emulsion explosives, coolants like sodium chloride are added to reduce the flame temperature.

Slurry/Emulsion explosives can be manufactured at site through Site Mix Slurry (SMS) or Site Mix Emulsion (SME) systems and charged into boreholes mechanically through pumping arrangement. These explosives are water resistant, fairly stable, sensitive and have good storage quality. They are sensitive to shock impact and fire and are non-toxic. They have excellent fume characteristics and post-blast fumes are non-irritating.

Assistance has been drawn from the UN Test Series 3(c) 'Transport of dangerous goods — Manual of tests and test criteria'.

This standard is in the series of Indian Standards on commercial blasting explosives. The other standard on commercial blasting explosives deals with nitroglycerine-bases explosives [IS 15447(Part 1) : 2004 Commercial blasting explosives: Part 1 Nitroglycerine based explosives — Specification].

The composition of the Committee responsible for the formulation of this standard is given in Annex D.

There is no ISO specification for the product.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

COMMERCIAL BLASTING EXPLOSIVES

PART 2 SLURRY/EMULSION EXPLOSIVES — SPECIFICATION

1 SCOPE

This standard (Part 2) prescribes requirements and methods of test for slurry/emulsion explosives.

2 REFERENCES

The standards listed below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

IS No.	*Title*
1260 (Part 1) : 1973	Pictorial marking for handling and labelling of goods: Part 1 Dangerous goods (*first revision*)
6609	Methods of test for commercial blasting explosives and accessories:
(Part 2/Sec 1) : 1973	Explosives, Section 1 Explosives, general
(Part 2/Sec 2) : 1974	Explosives, Section 2 Explosives, permitted
(Part 2/Sec 3) : 1980	Explosives, Section 3 Explosives, slurry
10081 : 1981	Glossary of terms relating to commercial explosive pyrotechnics and blasting practices
10212 (Part 1) : 1986	General requirements for packages of commercial explosives: Part 1 Commercial high explosives (*first revision*)

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 10081 shall apply.

4 REQUIREMENTS

The slurry/emulsion-based commercial blasting explosives shall conform to the requirements prescribed in Table 1.

5 PACKING AND MARKING

5.1 Packing

The slurry/emulsion-based commercial blasting explosives shall be packed in suitable packages conforming to the requirements prescribed in IS 10212 (Part 1).

5.2 Marking

Each package shall be marked with the following information:

a) Indication of the source of manufacture;
b) Name of the explosives;
c) Batch number;
d) Date of manufacture;
e) Permitted/Non-permitted; and
f) CCE approval number of the box manufacturer.

5.2.1 Each package shall also be marked with appropriate explosive symbol as specified in IS 1260 (Part 1).

5.2.2 In addition to the above, the following cautionary note shall also appear on the label in red ink:

> HIGHLY EXPLOSIVE. HANDLE WITH UTMOST CARE. DO NOT DROP OR SUBJECT TO HEAT, FRICTION OR SHOCK. DO NOT BRING ANY SPARK OR FIRE NEAR THE PACKAGE.

5.2.3 *BIS Certification Marking*

The product may also be marked with the Standard Mark.

5.2.3.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

5.3 The packing and marking of slurry/emulsion bases commercial blasting explosives shall further conform to the provisions of the *Indian Explosives Rules*, 1983.

6 SAMPLING

6.1 Preservation

All sample shall be kept in water proof container/

Table 1 Requirements of Slurry/Emulsion-Based Commerical Blasting Explosives
(*Clause* 4)

Sl No. (1)	Characteristic (2)	Requirement (3)	Method of Test, Ref to (4)
i)	Air gap sensitivity	For small diameter cartridges (20-32 mm): a) Permitted explosives — Not less than 2 cm b) Non-permitted explosives — Not less than 2 cm	Clause **3.6** of IS 6609 (Part 2/Sec 1)
ii)	Velocity of detonation (VOD) (Unconfined) at 25°C ± 5°C ambient temp	Permitted — 2 800 m/s , *Min* Non-permitted — 3 000 m/s, *Min*	Clauses **3.7** to **3.9** of IS 6609 (Part 2/Sec 1) (Micro meter or dautriche test)
iii)	Power percent, *Max*	Non-permitted — 50–90 percentage As agreed to between the purchaser and the manufacturer Permitted— P1 : 50 and above P3 : 40 and above P5 : 35 and above	Clause **3.11** of IS 6609 (Part 2/Sec 1)
iv)	Water proofness test (Small dia and large dia)	To pass the test (when tested at 24 h)	Annex A
v)	Impact sensitivity with 10 kg load from a distance of 1.1 m	No detonation in 10 tests	Clause **3.4** of IS 6609 (Part 2/Sec 1)
vi)	Thermal stability test	To pass the test at 75°C for 48 h	Annex B
vii)	Sensitivity to initiation	No. 6/8 Detonator (for permitted explosives) Detonator/Booster (for non-permitted explosives)	Clause **4.0** of IS 6609 (Part 2/ Sec 3)
viii)	Gallery test	a) P1: Series I — 13/26 Series II — Nil/5 Series III — Nil/5 b) P3: Series I —13/26 Series II — Nil/5 Series III — Nil/5 c) P5: Series I — Nil/20 Series II — Nil/5 Series III — Nil/5	IS 6609 (Part 2/Sec 2)
ix)	Continuity of detonation (COD) [small dia]	To pass the test	IS 6609 (Part 2/Sec 2)
x)	Density g/cm^3	0.8–1.35	Annex C
xi)	Size of cartridges	±2 percent tolerance	
xii)	Shelf life, *Min*	6 months	Clause **3.6** of IS 6609 (Part 2/ Sec 1)
xiii)	Deflagration for P5 permitted explosives	Not more than 1 cm	IS 6609 (Part 2/Sec 2)

NOTES

1 Characteristics against Sl No. (ix) and (xiii) applicable only to permitted explosives.

2 The requirement prescribed for Sl No. (iii) shall be if desired by the user.

polythene cover till they are taken for testing to protect them from water and other atmospheric changes.

6.2 Lot

Cases of slurry/emulsion-based commercial blasting explosives of same variety (Permitted or non-Permitted), same type (Based on power) and same size belonging to different batches grouped together to constitute a lot.

6.2.1 Cartridges of slurry/emulsion-based blasting explosives constituting sample shall be drawn from each lot separately for deciding the conformity of the lot to the requirements of the specification.

6.3 Small Diameter Explosives

6.3.1 Number of slurry explosives cartridges to be selected at random from the lot shall depend on the lot size and shall be in accordance with Table 2.

Table 2 Scale of Sampling of Slurry Based Explosives
(*Clause* 6.3.1)

Sl No. (1)	Lot Size mt (2)	Sample Size (3)
i)	Up to 10	10 No. of cartridges
ii)	Up to 10-20	20 No. of cartridges
iii)	above 20	30 No. of cartridges

NOTE — Extra cartridges taken in case of larger lot size shall be used for repeating the following tests with additional cartridges for conformation of uniformity.

6.3.2 *Number of Tests*

The number of cartridges to be drawn from each lot for carrying out various tests shall be as given below:

Sl No.	*Test*	*No. of Cartridges to be Tested*
i)	Air gap sensitivity	2
ii)	Velocity of detonation unconfined, m/s	1
iii)	Power percent (deleted)	2
iv)	Water proofness	2
v)	Impact sensitivity	2
vi)	Stability	1
vii)	Sensitivity to the initiation	5
viii)	Continuity of detonation	5
ix)	Density, g/cc	1

Tests (i) and (vii) to be done on every lot and (ii) and (viii) every 15 lots. Tests (iv) to (vi) that is water proofness, impact sensitivity, stability tests are type tests and should be done as and when needed.

6.4 Gallery Test

Gallery test is a type of test and it is not required to be carried out on every lot, if the particular type of composition has been tested by Central Mining Research Institute and approved by Director General of Mines Safety. But repeat incendivity test shall be done once in every two years of each approved sample of permitted explosive for checking its consistency against safety.

6.4.1 *Scale of Sample*

Samples for gallery test shall be fixed based on the requirements furnished by the Central Mining Research Institute from time-to-time.

6.5 Large Diameter (*See* Table 3)

Table 3 Scale of Sampling of Slurry/ Emulsion Explosives

(*Clause* 6.5)

Sl No.	**Lot Size mt**	**Sample Size**
(1)	(2)	(3)
i)	Up to 10	8 to10 No. of cartridges

NOTE — All the tests shall be in accordance with **6.2.1**. Only velocity of detonation shall be tested using full cartridges. other tests shall be tested using half or part of the cartridges.

6.6 Criteria for Conformity

For deciding the conformity of the lot to the requirement of the specification, the test results of each characteristics shall meet the corresponding requirement specified in the relevant clauses.

ANNEX A

[*Table* 1, *Sl No.* (iv)]

PROCEDURE FOR WATER PROOFNESS TEST

A-1 OBJECTIVE

To find out the water prootness of the slurry based industrial explosives.

A-2 PROCEDURE

A-2.1 Preparation of Samples

Take 5 cartridges of 32 mm diameter 210 mm long cartridges of freshly prepared permitted slurry explosives. Make five 6 mm dia and 15 mm depth holes on the surface of the cartridges in the form of a spiral, each hole 25 mm apart in such a way that first hole is more than 50 mm apart from one end of the cartridge. The holes shall be such that the first, third and the fifth holes are in line with each other. At the other end of the cartridge, make detonator hole in such a way that the last hole is at least 25 mm away from the detonator. Plug the detonator holes with wooden sticks.

A-3 STORAGE OF THE SAMPLES UNDER WATER

Take a metal trough of more than 20 cm height and place all the five cartridges in the trough horizontally. Fill the trough with water such that there was 15 cm. Water level above the top surface of the cartridges.

A-4 EXAMINATION AND FIRING OF THE SAMPLES

Take out the cartridges at the interval of 1, 2, 3, 4 and 24 h and examine for any physical change. Fire the cartridges using No. 6 electric detonators and measure their velocity of detonation by Dautriche method.

A-5 RESULTS

Observe all the five cartridges for any change in the shape or sogginess after 24 h of storage in water. All the cartridges are fired with No.6 electric detonator and their velocities of detonation were measured. Also record the extent of detonation of the cartridges and compare their velocity of detonation with the initial VOD (change in VOD shall be within the limits of experimental errors).

ANNEX B

[*Table* 1, *Sl No.* (vi)]

THERMAL STABILITY TEST

B-1 GENERAL

This test is used to measure the stability of the substance when subjected to elevated thermal conditions to determine if the substance is too dangerous to transport.

B-2 APPARATUS AND MATERIALS

B-2.1 The following apparatus is required.

B-2.1.1 *Electric Oven* — Equipped with ventilation, explosion-proof electric features, and thermostatic control adequate to maintain and record the temperature at 75 ± 2°C. The oven should have dual thermostats or some kind of protection against thermal run-away, if the thermostat malfunctions.

B-2.1.2 *Lipless Beaker*, of 35 mm diameter and 50 mm high and a watch-glass of 40 mm diameter.

B-2.1.3 *Balance*, capable of determining the sample weight upto ± 0.1 g.

B-2.1.4 Three thermocouples and a recording system.

B-2.1.5 Two flat-bottomed glass tubes of 50 ± 1 mm diameter and 150 mm length and two 0.6 bar (60 kPa) pressure resisting stoppers.

B-2.2 Reference Substance

An inert substance, whose physical and thermal properties are similar to the test substance, should be used as the reference substance.

B-2.3 Procedure

B-2.3.1 In dealing with a new substance, several screening tests, involving heating small samples at 75°C for 48 h, are performed to explore its behaviour. If no explosive reaction occurs using a small amount of substance, the procedure given in **B-2.3.2** or **B-2.3.3** should be used. If explosion or ignition occurs then the substance is too thermally unstable for transport.

B-2.3.2 *Uninstrumented Test*

Weigh a 50 g sample into a beaker, cover and place in an oven. Heat to 75°C and leave the sample at oven temperature for 48 h or until ignition or explosion occurs, whichever is sooner. If ignition or explosion does not occur but there is evidence, for example fuming or decomposition, that some self-heating has occurred, the procedure given in **B-2.3.3** should be performed. However, if the substance shows no evidence of thermal instability, it may be regarded as thermally stable and no further testing of this property is necessary.

B-2.3.3 *Instrumented Test*

A 100 g (or 100 cm^3 if the density is less than 1 000 kg/m^3) sample is placed in one tube and the same quantity of reference substance is placed in the other. Thermocouples T_1 and T_2 are inserted into the tubes at half-height of the substances. If the thermocouples are not inert with respect to both the substance being tested and the reference substance, they should be enclosed in sheaths, which are inert. Thermocouple T_3 and the covered tubes are placed in the oven as shown in Fig. 1. The temperature difference (if any) between test sample and reference is measured for 48 h after the sample and any reference substance reach 75°C. Evidence of decomposition of the sample is noted.

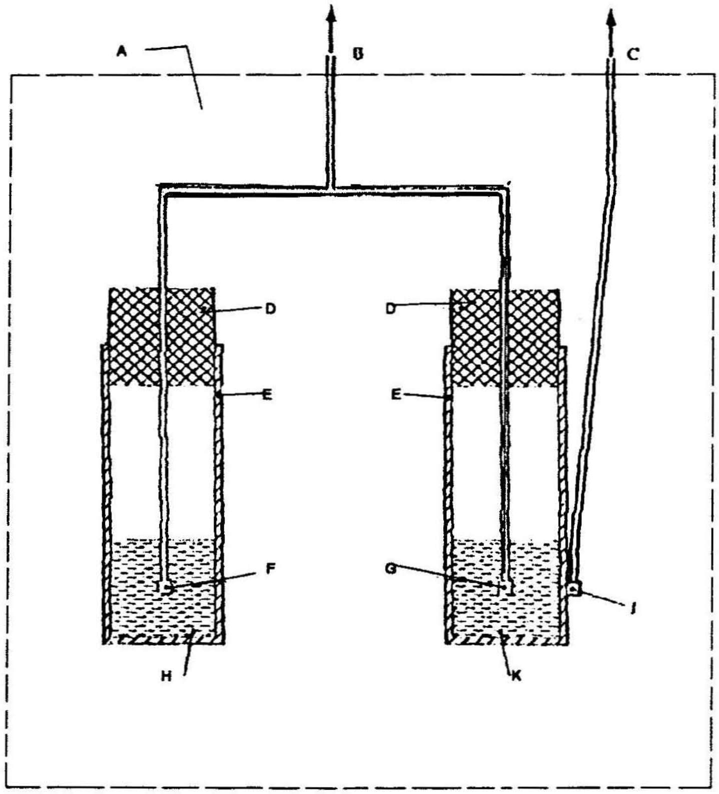
B-2.3.4 *Test Criteria and Method of Assessing Results*

B-2.3.4.1 The result from an uninstrumented test is considered '+' if ignition explosion occurs and '–' if no changes are observed. The result of a instrumented test is considered '+' if an ignition or explosion occurs or if a temperature difference (that is, self heating) of 3° C or greater is recorded. If no ignition or explosion occurs but self-heating of less than 3° C is noted, additional tests and/or evaluation may be required to determine if the sample is thermally unstable.

B-2.3.4.2 If the test result is '+', the substance should be considered too thermally unstable for transport.

B-2.3.5 *Examples of Results*

Substances Result	*Observations*
70 percent AP, 16 percent Al 2.5 percent Catocene, 11.5 percent binder	Oxidation reaction took place on Catocene (burning rate catalyst). Sample discoloured on the surface, but there was no chemical decomposition
PETN/Wax 90/10	Negligible mass loss
RDX, 22 percent water wetted	Mass loss < 1 percent
Gelatine dynamite (NG 22 percent, DNT 8 percent, Al 3 percent)	Negligible mass loss
ANFO explosive	Mass loss < 1 percent
Slurry explosives ±	Negligible mass loss, slight (eventual) swelling



A — Heating oven
B — To millivoltmeter (T_1–T_2)
C — To millivoltmeter (T_3)
D — Stoppers
E — Glass tubes
F — Thermocouple No. 1 (T_1)
G — Thermocouple No. 2 (T_2)
H — 100 cm³ of sample
J — Thermocouple No. 3 (T_3)
K — 100 cm³ of reference substance

FIG. 1 EXPERIMENTAL SET-UP FOR STABILITY TEST AT 75°C

ANNEX C

[*Table* 1, *Sl No.* (x)]

DETERMINATION OF SPECIFIC GRAVITY BY FLOAT AND SINK METHOD

C-1 QUALITY OF REAGENTS

Unless specified otherwise, pure methanol and distilled water shall be employed for the tests.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the results of analysis.

C-2 PREPARATION OF THE SAMPLE

C-2.1 Procedure for Making Specific Gravity Solutions in the Range of 0.8 to 1.00

Mix methanol and water in ratios of 30 percent, 50 percent, 80 percent and 95 percent by weight of methanol. Measure the specific gravity of the mixtures in a measuring cylinder using calibrated hydrometers of the required range at 30° C. Make stock solutions of specific gravity approximately 0.945, 0.915, 0.842 and 0.802 respectively. Transfer the stock solutions into stopper bottles.

C-2.1.1 *Preparation of Specific Gravity Solutions of 1.00 to 1.4*

Prepare a strong solution of uncoated ammonium nitrate, sodium nitrate and water in the ratio of 8:1:1 by heating the mixture at 80°C. The specific gravity of this solution should be more than 1.5 at 80°C.

C-2.2 Take portions of this solution and dilute it separately with water using hydrometers. Make standard solutions of desired specific gravity, for example 1.1, 1.15, 1.2, 1.25, 1.3, 1.35 and 1.40 at 30°C. Store these solutions in stopper plastic or glass bottles with proper labels.

C-2.3 Measurement of Specific Gravity of Sample

Pour about 200-250 ml of standard solution from the bottles in clean and dry beakers of 300-350 ml capacity plastic/glass beakers individually.

C-2.3.1 Cut about 1.5" portion of the layflat (wrapper) at the center (or as required) of the cartridge by a sharp blade/knife and take out gently a small portion (about 1.0 g) of emulsion with the help of a horn spatula.

C-2.3.2 Drop the slurry/emulsion sample from the spatula into one of the beakers containing standard solution (say it is dropped in the solution of 1.15 specific gravity).

C-2.3.3 Watch the behaviour of the sample in the standard solution. It may either float or sink. If it floats, it indicates that the density of the emulsion is less than 1.15. Therefore, another sample has to be taken out from the cartridge in the similar way and dropped into the standard solution of specific gravity 1.10.

C-2.3.4 If the sample sinks in 1.10 solutions, the specific gravity of the emulsion/slurry sample is reported as 1.10-1.15.

C-2.3.5 In case the first sample sinks in the standard solution of specific gravity of 1.15, a fresh sample from the cartridge is to be taken out and checked in the standard solution of specific gravity of 1.20 and so on.

C-2.3.6 Immediately after the test is over, take out the sample pieces of emulsions from the standard solutions and transfer the standard solutions back into the respective bottles. Clean the beakers, spatula and the blade/knife.

C-2.3.7 If the cartridges are needed further, put cello tape in the cut portions and keep them properly, otherwise they can be disposed off along with emulsion/slurry samples in the explosives waste bin for destruction in the burning station.

C-2.3.8 The specific gravity of the standard solution has to be checked and adjusted accordingly either by diluting with water, methanol or adding strong solution of AN/SN/Water mixture.

NOTE — Before starting test check the specific gravity of the bottle solution and adjust if necessary.

ANNEX D

(Foreword)

COMMITTEE COMPOSITION

Explosives and Pyrotechnics Sectional Committee, CHD 26

Organization	*Representative(s)*
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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

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